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ORIGINAL ARTICLE

Three new genera of the family Nesticidae (Arachnida: Araneae) from Tibet and Yunnan, China

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Abstract Three new genera of the spider family Nesticidae, *Hamus* **gen. nov.**, *Nescina* **gen. nov.** and *Wraios* **gen. nov.**, are reported. Three new species, *Hamus bowoensis* **sp. nov.**, *Nescina minuta* **sp. nov.** and *Wraios longiembolus* **sp. nov.**, showing remarkable characters in palpal and epigynal morphology, are described based on specimens collected in Tibet and Yunnan, China. All the type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS) in Beijing.

Key words Nesticids, taxonomy, type, diagnosis, etymology.

1 Introduction

Family Nesticidae, a relatively small family of spiders, has a worldwide distribution. To date, 225 species have been described belonging to 10 genera (World Spider Catalog, 2015). Most of the currently known species occur in Holarctic temperate areas, where they are mainly restricted to cave-like environments and exhibit a middle-sized, long legged body and different adaptations to troglophilic life. In contrast, nesticids living in tropical or subtropical habitats are mostly smaller than their Holarctic counterparts and they exhibit shorter legs and minor adaptations to the cave environment. They also occur frequently outside caves in forest litter, grass and under stones (Lehtinen & Saaristo, 1980).

Most researchers especially in Europe, Japan and North America concentrate their studies on species from the cave-like environments. The so called “short-legged Nesticidae” have been studied far less. In 1980, Lehtinen and Saaristo first noted the diversity of nesticids in Oriental and Australian Regions. They described some new species and grouped them into the genera *Nesticella* Lehtinen & Saaristo, 1980 and *Howaia* Lehtinen & Saaristo, 1980 in the tribe Nesticellini. Wunderlich (1986) wrongly synonymized the two genera, we will report detailed evidence that *Howaia* is a valid genus in a following paper. Today, *Nesticella* includes the wide majority of species in East and Southeast Asia with the exclusion of Japan, where the genera *Nesticus* Thorell, 1869 and *Cyclocarcina* Komatsu, 1942 dominate.

The importance of southern and central China as a center of diversity for the Nesticidae is apparent due to the description of several new species of *Nesticella* and *Nesticus* (Liu & Li, 2013a) and a new genus, *Pseudonesticus* (Liu & Li, 2013b). New work on the evolutionary history of *Nesticella* from the Yunnan-Guizhou Plateau further suggests a wide and recent diversification of these spiders in that area and the possible existence of unknown cryptic species (Zhang & Li, 2013). It is likely that arachnologists have only scratched the surface of the variety of nesticids in Asia. The majority of species and genera likely await discovery.

Our work sheds light on the diversity of nesticids in Asia. We focus mainly on the Chinese areas of Tibet and Yunnan. Herein, we describe three new species and we establish new genera for each one. The new genera show peculiar characters that clearly distinguish them from all the currently known genera of Nesticidae.

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2 Material and methods

The spiders were collected by sifting litter in Tibet and Yunnan (Fig. 7). Spiders were immediately put in 95% ethanol for further studies. The specimens were studied using a LEICA M205 C stereomicroscope and photographed with an Olympus c7070 digital camera. Images were mounted using Helicon Focus and Combine ZP image stacking software. Epigynes were dissected and cleared by boiling them in a 10% KOH solution before being embedded in arabic gum to take the photos of the vulva. Leg measurements were taken from the lateral side. All measurements were taken in millimeters. The left palp was illustrated and described. In one case (*Nescina minuta* **sp. nov.**) the right palp was photographed because of its better condition and the images were digitally reversed for comparison. The following abbreviations are used in the text and figures: Ac = apex of the conductor, C = conductor, Co = copulatory opening, Cp-I = conductor process I, Cp-II = conductor process II, Da = dorsal apophysis of the paracymbium, Dp = distal process of the paracymbium, E = embolus, Ep = epigynal plate, Fd = fertilization duct, Id = insemination duct, Lf = lateral cymbial furrow, P = paracymbium, S = spermatheca, St = subtegulum, T = tegulum, Ta = terminal apophysis, Ta-I = terminal apophysis process I, Ta-II = terminal apophysis process II, Tg = tegular apophysis, Tg-I = tegular apophysis process, Va = ventral apophysis of the paracymbium.

All types are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS) in Beijing, China.

3 Systematics

Family Nesticidae Simon, 1894

Genus *Hamus* gen. nov.

Type species: *Hamus bowoensis* **sp. nov.**

Etymology. The generic name is derived from the Latin word "*hamus*" meaning "hook". The term refers to the shape of processes of the terminal apophysis and of the conductor in the nominal species. The gender is masculine.

Diagnosis. Several characters diagnose the genus as new in the Nesticidae. For the male, the short paracymbium ending with a hooked process, the apex of the embolus ending in the center of the palpal bulb, the shape of the terminal apophysis with its C-like hooked processes and the distally swollen palpal femur. A long and laminar conductor with a counterclockwise course also occurs in *Nescina* **gen. nov.**, however *Hamus* **gen. nov.** has two strongly sclerotized processes at the base of the conductor while only a single laminar process is present in *Nescina* **gen. nov.** (Figs 1B and 3B). This structure, together with the difference of size and all the other diagnostic characters in male palp and epigyne, clearly distinguish the two genera. The tuft of hair present on the femur I of the male is also helpful to separate this genus from all the others. Females have massive spermathecae visible through the tegument and peculiar orientation of the insemination ducts.

Distribution. China (Tibet).

***Hamus bowoensis* sp. nov.** (Figs 1–2, 7)

Material examined. Holotype ♂, 30 August 2010, China, Tibet, Nyingchi, Bowo County (29°51'49.1754"N, 95°46'24.528"E), elev. 2 731 m. Paratypes 2 ♀, 12 August 2014, China, Tibet, Nyingchi, Bowo County, Yigong Town, Kaduo Village (30°7'30.9"N, 95°1'55.6788"E), elev. 2 072 m, leg. Yun-Chun Li.

Etymology. The specific name is derived from the type locality; adjective.

Diagnosis. The new species can be easily recognized by the shape of the male palpal cymbium with a large cymbial furrow, by the general appearance of the short paracymbium and its terminal hooked process and by the two massive hook-like processes of the terminal apophysis (Figs 1A–D). The two sclerotized processes at the base of the conductor, the

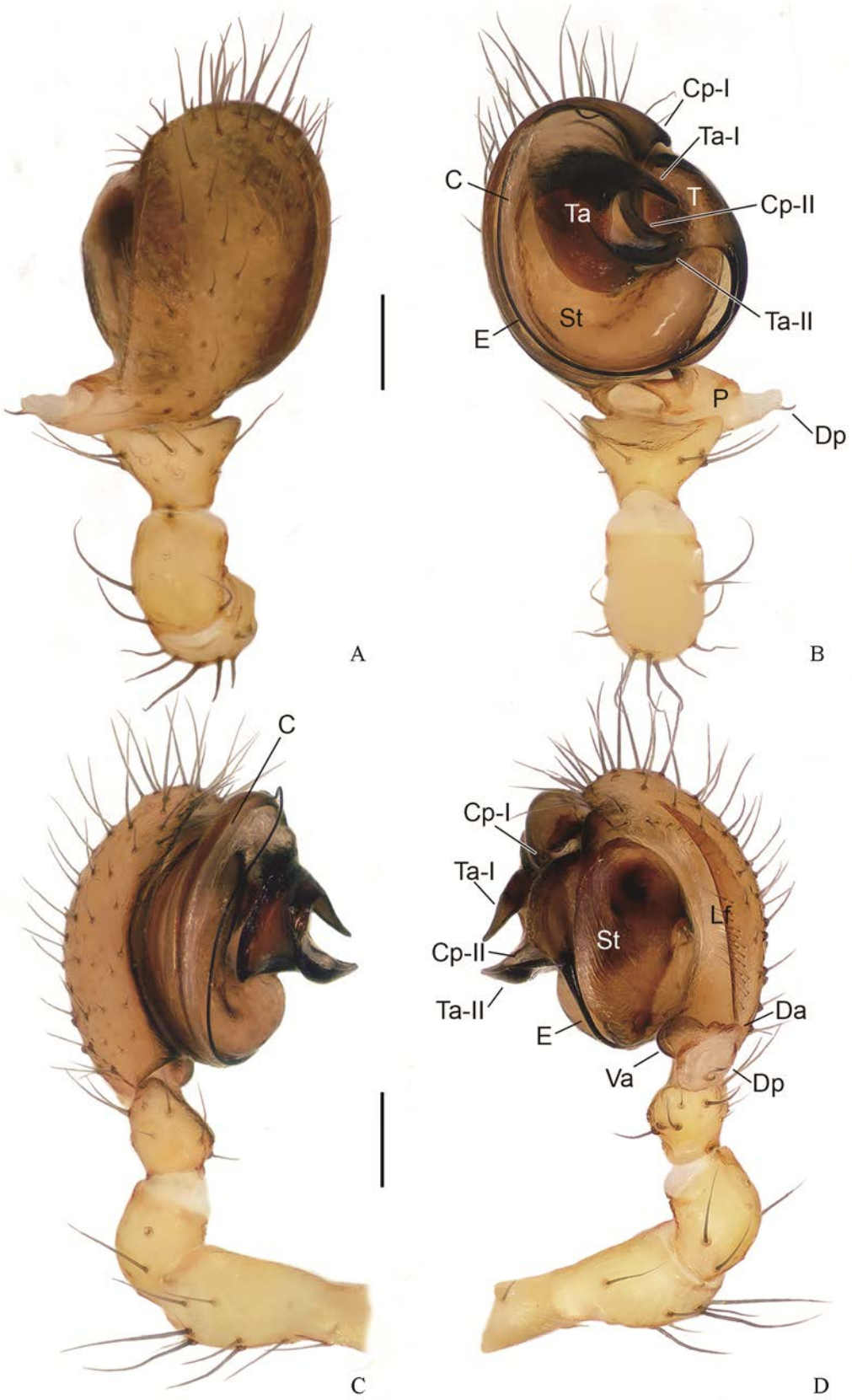

Fig. 1. *Hamus bowoensis* **sp. nov.**, male palp. A. Dorsal view. B. Ventral view. C. Prolateral view. D. Retrolateral view. Scale bars = 0.1 mm.

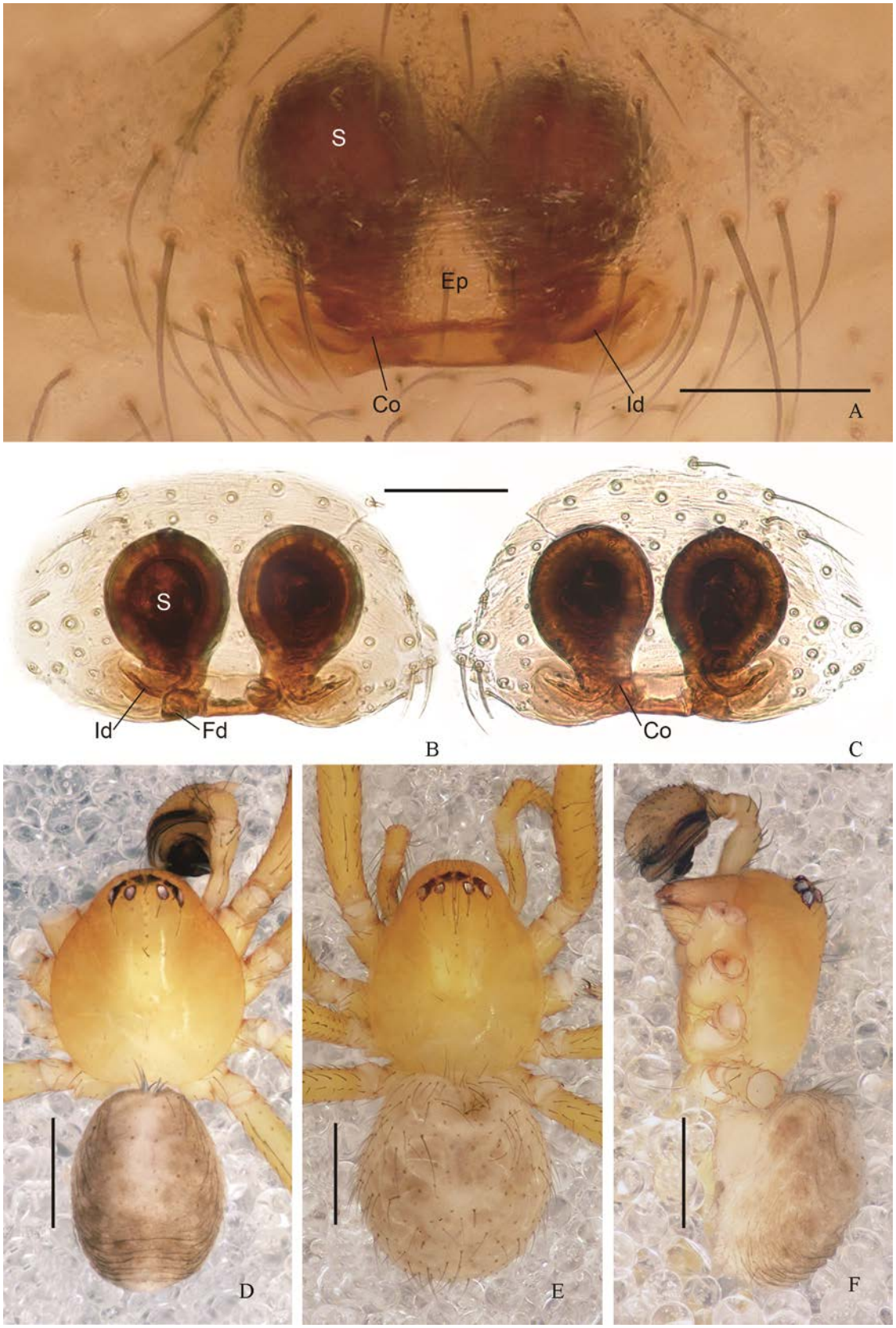

Fig. 2. *Hamus bowoensis* **sp. nov.** A. Epigyne, ventral view. B. Vulva, dorsal view. C. Vulva, ventral view. D. Male habitus, dorsal view. E. Female habitus, dorsal view. F. Male habitus, lateral view. Scale bars: A–C = 0.1 mm; D–F = 0.5 mm.

distally swollen palpal femur and the tuft of hair on the femur I are also helpful characters to separate males of *H. bowoensis* **sp. nov.** from the males of all the other known species. The general appearance of the epigyne (Figs 2A, C), with the large spermathecae visible through the tegument and the orientation of the insemination and fertilization ducts (Fig. 2B) are diagnostic to distinguish the female.

Description. Male (holotype). Total length 1.87. Carapace length 1.01, width 0.89. Leg formula: I, IV, II, III. Leg measurements: I: 1.34, 0.38, 1.27, 0.81, 0.71 (4.51); II: 1.13, 0.38, 1.02, 0.76, 0.77 (4.06); III: 0.92, 0.32, 0.67, 0.57, 0.59 (3.07), IV: 1.43, 0.38, 1.06, 0.74, 0.72 (4.33). Habitus as in Figs 2D, F. Prosoma approximately circular in dorsal view, uniformly yellow. Fovea visible as a deep depression. Cephalic area slightly raised but clearly distinct from the rest of the prosoma. Chelicera yellow with three teeth on the promargin. Clypeus, labium and sternum of the same color. Labium rebordered. Legs uniformly yellow, femur I with a tuft of hairs on the prolateral margin. Metatarsal trichobothrium position (TmI) = 0.4. Metatarsus IV with a ventral row of long, serrated bristles (tarsal comb). Opisthosoma gray with a faint, lanceolate lighter area. Ventral side uniformly light gray.

Palp (Figs 1A–D) uniformly yellow with a darker bulb, rounded and ventrally flat. Palpal femur distally swollen. Long lateral cymbial furrow (Lf) on the retrolateral side of the cymbium. Paracymbium short, transversally oriented to the cymbium and ending with a flat, transparent lobe and a short, hooked distal process (Dp). A small, blunt dorsal apophysis (Da) and a lobed ventral apophysis (Va) are present. Terminal apophysis strongly sclerotized with a flat, rounded base and two hooked processes (Ta-I, Ta-II) ventrally and inward oriented forming a C-like structure. Tegular apophysis not visible. Embolus (E) filamentous, starting from the left side of the palp and continuing with a circular, clockwise course bordering the subtegulum and ending in centre of the bulb. Conductor (C) shaped as a long plate, starting in the frontal part of the bulb and following the embolus on the prolateral side with a counterclockwise course. A hooked, blunt process (Cp-I) is present on the frontal margin; a second, elongated process (Cp-II) is bended ventrally and leading the terminal part of the embolus in the center of the bulb near the tip of the Ta-II.

Female (one of the paratypes). Total length 2.15. Carapace length 1.08, width 0.89. Leg formula: I, IV, II, III. Leg measurements: I: 1.39, 0.41, 1.21, 0.87, 0.71 (4.59); II: 1.18, 0.39, 0.93, 0.72, 0.67 (3.89); III: 0.93, 0.36, 0.67, 0.56, 0.58 (3.10); IV: 1.34, 0.4, 1.11, 0.76, 0.69 (4.3). Habitus as in Fig. 2E. Prosoma oval in dorsal view. Palp with a long pectinate claw. Femur I without the tuft of hairs. All other characters as in the male.

Epigyne and vulva as in the Figs 2A–C. Posterior edge of the epigynal plate (Ep) slightly sclerotized. Spermathecae (S) and insemination ducts (Id) can be observed through the tegument. Insemination ducts making a large, flat spiral before reaching the spermathecae with several coils. Fertilization ducts (Fd) short and ventrally oriented. Spermathecae very large, oval and close to each other.

Habitat. Litter of mountain forests over 2 000 m.

Distribution. Known only from the type locality.

Genus *Nescina* gen. nov.

Type species: *Nescina minuta* **sp. nov.**

Etymology. The generic name is an arbitrary combination of letters inspired by the word "*Nesticus*", the nominal genus of the family Nesticidae. The gender is feminine.

Diagnosis. The new genus is diagnosed by the remarkably small size, the elevated cephalic area clearly separate from the prosoma, the flat terminal apophysis with a laminar and a small hook-like processes and by the simple, hooked shape of the paracymbium. The ventrally flat appearance of the palpal bulb also contributes to make the new genus peculiar within the Nesticidae. The general shape of the conductor and its elongated lamina recalls the similar structure present in *Hamus* **gen. nov.** although all the other characters clearly identify them as different genera (Figs 1B and 3B). The epigyne appearance and shape of the long, twisted insemination ducts are diagnostic for the female and are unique within the family.

Distribution. China (Yunnan).

***Nescina minuta* sp. nov.** (Figs 3–4, 7)

Material examined. Holotype ♂, 20 June 2013, China, Yunnan, Xishuangbanna, Mengla County, Xiaolongha Village, Gougu forest, biodiversity protection corridor (21°24'19.3206"N, 101°37'0.5406"E), elev. 808 m, tropical seasonal rain

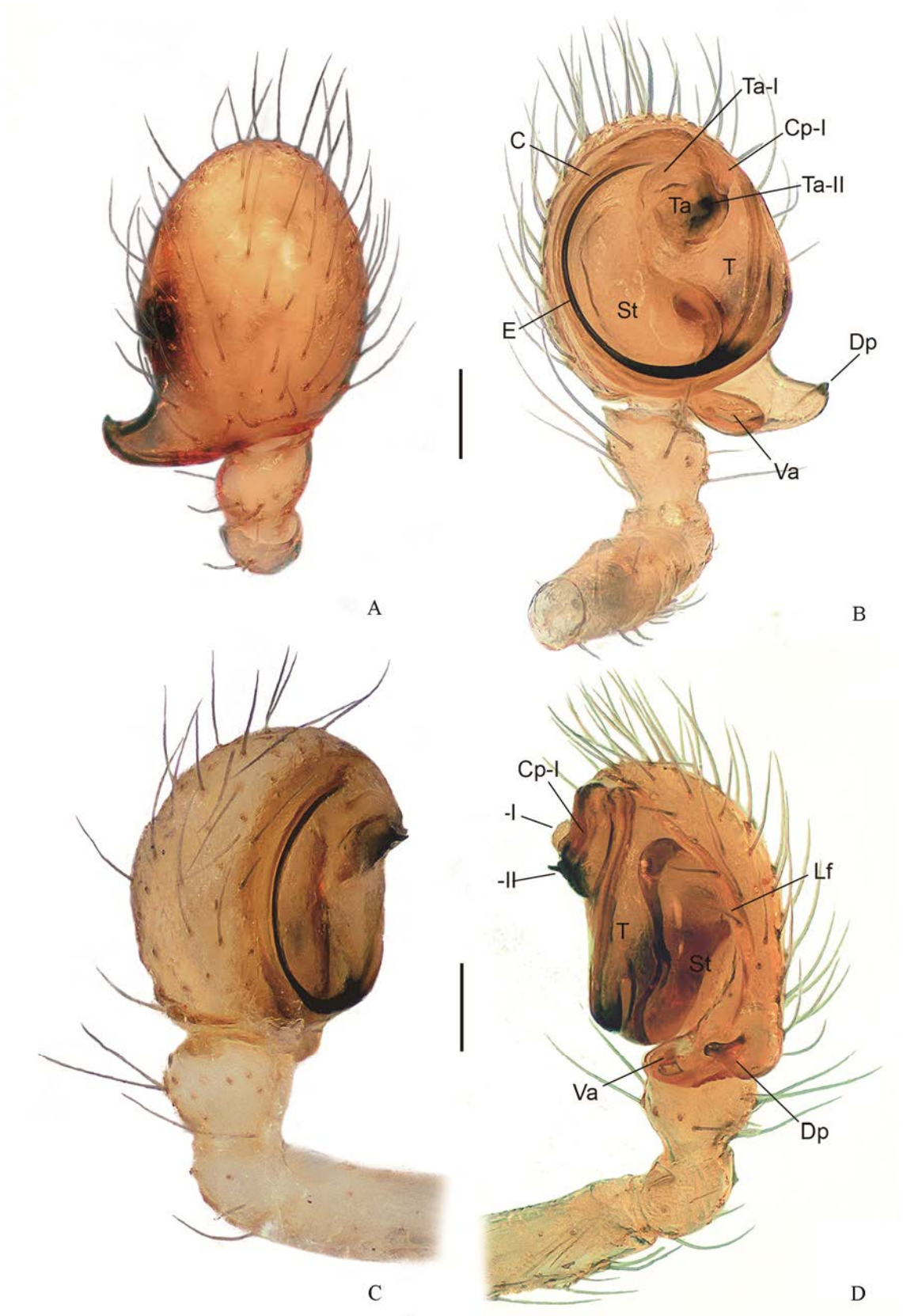

Fig. 3. *Nescina minuta* **sp. nov.**, male palp. A. Dorsal view. B. Ventral view. C. Prolateral view. D. Retrolateral view. Scale bars = 0.1 mm.

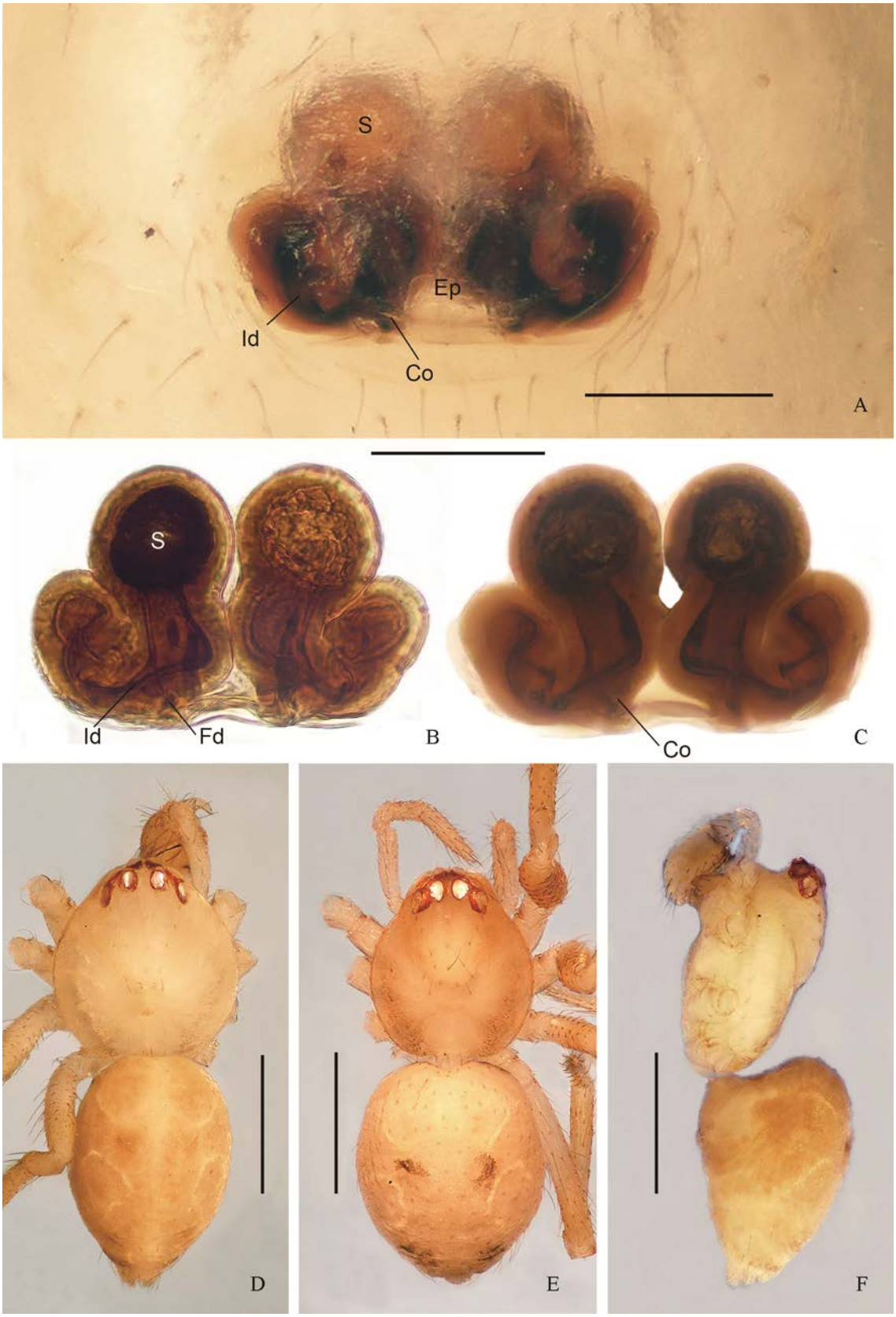

Fig. 4. *Nescina minuta* **sp. nov.** A. Epigyne, ventral view. B. Vulva, dorsal view. C. Vulva, ventral view. D. Male habitus, dorsal view. E. Female habitus, dorsal view. F. Male habitus, lateral view. Scale bars: A–C = 0.1 mm, D–F = 0.5 mm.

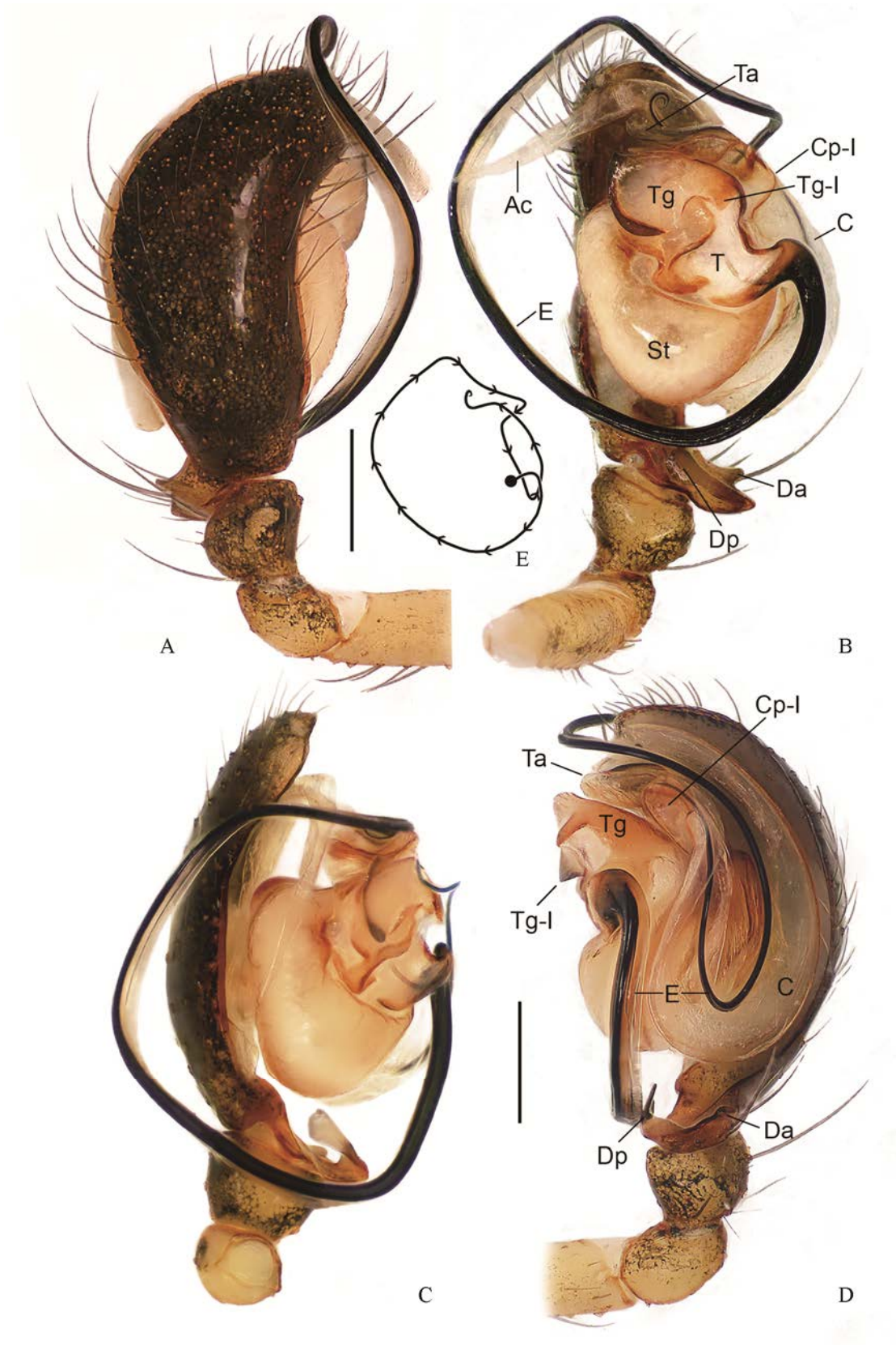

Fig. 5. *Wraios longiembolus* **sp. nov.**, male palp. A. Dorsal view. B. Ventral view. C. Prolateral view. D. Retrolateral view. E. Schematic course of the embolus in ventral view. Scale bars = 0.2 mm.

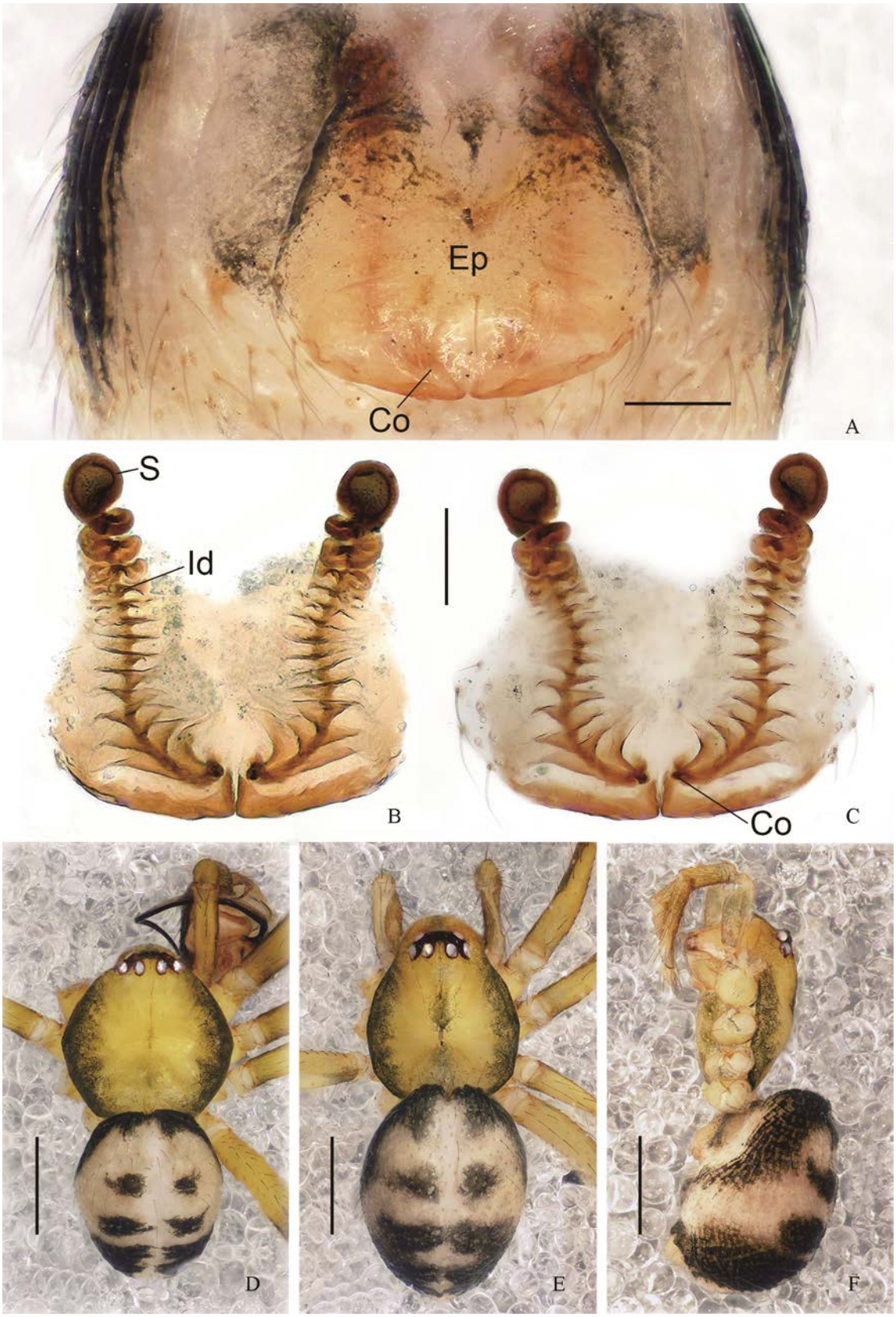

Fig. 6. *Wraios longiembolus* **sp. nov.** A. Epigyne, ventral view. B. Vulva, dorsal view. C. Vulva, ventral view. D. Male habitus, dorsal view. E. Female habitus, dorsal view. F. Female habitus, lateral view. Scale bars: A–C = 0.1 mm, D–F = 0.5 mm.

forest, in the litter, sieving, leg. Qing-Yuan Zhao & Zhi-Gang Chen. Paratypes: 1 ♂, 4 ♀, same locality and date as holotype.

Etymology. The name is derived from the Latin word "*minutus*" meaning "tiny, very little", referring to the very small size of the species, unusual for the Nesticidae; adjective.

Diagnosis. The male of the new species can be easily separate from the other nesticids by the shape of the terminal apophysis, flat and rounded, and by its small processes (Figs 3B–D). The general appearance of the paracymbium, with a hook-like shape and a lobed ventral apophysis, and the laminar process at the base of the conductor (Figs 3A–B, D) are also diagnostic characters. Females can be distinguished by the main appearance of the epigyne and especially by the shape of the long, twisted insemination ducts, visible through the tegument. The small size, the dorsal pattern and the presence of 6 small teeth on the promargin of the chelicera can also help to distinguish the species.

Description. Male (holotype). Total length 1.56. Carapace length 0.74, width 0.67. Leg formula: I, IV, II, III. Leg measurements: I: 0.76, 0.21, 0.69, 0.43, 0.34 (2.43); II: 0.56, 0.18, 0.36, 0.34, 0.28 (1.72); III: 0.51, 0.18, 0.36, 0.32, 0.26 (1.63); IV: 0.62, 0.19, 0.53, 0.36, 0.28 (1.98). Habitus as in Figs 4D, F. Prosoma circular in dorsal view, uniformly pale yellow. Fovea visible as a deep depression. Cephalic area elevated and clearly differenced from the rest of the prosoma. Chelicera pale yellow with a row of 6 small teeth on the promargin, the 2 inner larger than the others. Clypeus, labium and sternum of the same color, labium rebordered. Legs uniformly pale yellow. Metatarsal trichobothrium position (TmI) = 0.45. Metatarsus IV with a ventral row of long, serrated bristles (tarsal comb). Opisthosoma oval in dorsal view, uniformly yellow with two or four faint black dots. Ventral side yellow, two fain dark marks at the sides of the spinnerets.

Palp (Figs 3A–D) uniformly pale yellow. Cymbium with a long cymbial furrow (Lf) on the retrolateral side. Paracymbium short, transversally oriented to the cymbium, with a hook-like distal process (Dp) bended ventrally and a wide, lobed ventral apophysis (Va). Terminal apophysis (Ta) shaped as a flat and rounded plate with one laminar process frontally oriented (Ta-I) and a small hook-liked process ventrally oriented (Ta-II). Tegular apophysis not visible. Embolus (E) filamentous with a clockwise semicircular course. Conductor (C) laminar, long and flat, starting from the frontal part of the bulb and following the embolus with a counterclockwise course on the prolateral side. A laminar process (Cp-I) is present at its base, near the terminal apophysis.

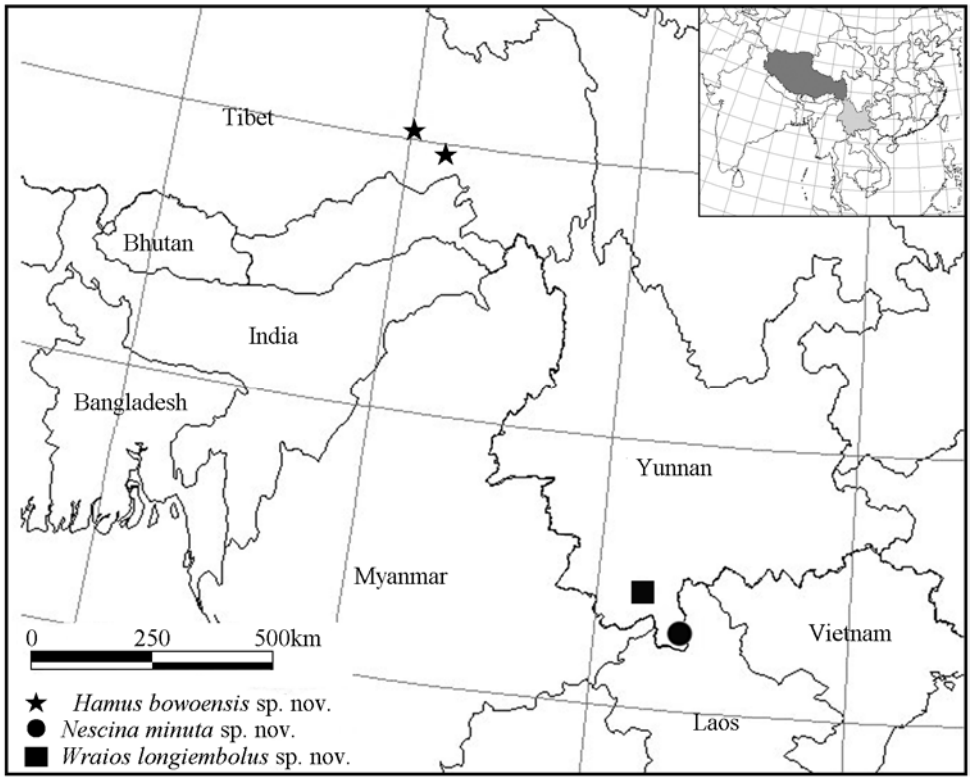

Fig. 7. Locality records of three new species of the family Nesticidae from China.

Female (one of the paratypes). Total length: 1.57. Carapace length 0.72, width 0.58. Leg formula: I, IV, II, III. Leg measurements: I: 0.69, 0.22, 0.57, 0.39, 0.41 (2.28); II: 0.59, 0.21, 0.47, 0.35, 0.31 (1.93); III: 0.5, 0.2, 0.35, 0.3, 0.26 (1.61); IV: 0.74, 0.19, 0.47, 0.41, 0.27 (2.08). Habitus as in Fig. 4E. Prosoma oval in dorsal view. Palp with a long claw. The four dots on the dorsal side of the prosoma are more clearly visible than in the male. Color and all the other characters as in the male.

Epigyne and vulva as in Figs 4A–C. Spermathecae (S) and insemination ducts (Id) can be observed through the tegument. Insemination ducts long and twisted, their course is oriented outward and inward at the sides of the copulatory openings, twisting on themselves before reaching the spermathecae. Fertilization ducts (Fd) short and ventrally oriented. Spermathecae large, rounded and close to each other.

Habitat. Litter of tropical seasonal forests.

Distribution. Known only from the type locality.

Genus *Wraios* gen. nov.

Type species: *Wraios longiembolus* **sp. nov.**

Etymology. The generic name is derived from the Greek word "ωραίος - wraios" meaning "lovely, nice", referring to the colorful pattern of the nominal species. The gender is masculine.

Diagnosis. The new genus has peculiar characters in the palpal, epigynal and vulval structure that clearly separate it from any other known genus of the family Nesticidae. Distinctive characters in the male are the extremely long and coiled embolus, the general shape of the paracymbium, the conductor and the axe-head shaped tegular apophysis. The wide, trapezoidal epigynal plate of the female, its coiled screw-shaped insemination ducts and the small spermathecae have no close similarities with any other nesticids genus.

Distribution. China (Yunnan).

***Wraios longiembolus* sp. nov.** (Figs 5–7)

Material examined. Holotype ♂, 27 June 2013, China, Yunnan, Xishuangbanna, Jinghong City, Guanping Town, Xishuangbanna Nature Reserve (22°13'38.7588"N, 100°53'20.8788"E), elev. 939 m, primary tropical seasonal rain forest, in the litter, sieving, leg. Qing-Yuan Zhao & Zhi-Gang Chen. Paratypes: 1 ♂, 14 ♀, same locality and date as holotype.

Etymology. The name is a combination of the Latin word "*longus*" meaning "long" and the word "*embolus*". It's referred to the very long embolus typical of this species; adjective.

Diagnosis. Males of the new species can be easily distinguished by the unusual shape of the embolus (Fig. 5E), extremely long and coiled around the cymbium, and by the shape of the conductor, strongly elongated and U-shaped, wrapped around the last part of the embolus and ending with a long, pointed apex (Figs 5B–D). The short paracymbium with a flat distal process bended inward and the shape of the tegular apophysis are also diagnostic (Figs 5B–D). The females can be separate from all the other species by the large, roughly trapezoidal epigynal plate and especially by the long and unusually strongly coiled copulatory ducts (Figs 6A–C). The dorsal pattern of both male and female (Figs 6D–E) can also help in the species identification.

Description. Male (holotype). Total length 1.72. Carapace length 0.91, width 0.86. Leg formula: I, IV, II, III. Leg measurements: I: 1.28, 0.39, 1.64, 1.39, 0.56 (5.26); II: 0.82, 0.34, 0.75, 0.74, 0.49 (3.14); III: 0.85, 0.3, 0.62, 0.71, 0.46 (2.94); IV: 1.01, 0.35, 0.87, 0.89, 0.5 (3.62). Habitus as in Fig. 6D. Prosoma circular in dorsal view, yellow, with two wide black stripes at the side borders. Fovea visible as a depression. Cephalic area not clearly differenced from the rest of the prosoma. Chelicera yellow with three teeth of the same length on the promargin. Clypeus dark, pointed onwards. Labium rebordered. Sternum uniformly dark gray. Legs yellow with black annulations on femur, patella, tibia and metatarsus. Metatarsal trichobothrium position (TmI) = 0.3. Metatarsus IV with a ventral row of long, serrated bristles (tarsal comb). Opisthosoma oval in dorsal view, grey with a black transverse stripe on the anterior margin extended on the lateral sides. Four black dots, more rarely only two, are present on the dorsal area; the dots are replaced in the posterior half of the prosoma by two black marks more or less merged to each other. In few samples the dots are less defined. Ventral side uniformly gray with a black area around the spinnerets.

Palp as in Figs 5A–D. Cymbium, tibia and partially patella black, femur and proximal part of the patella yellow. Paracymbium short distally ending with an enlarged, flat process (Dp) bended ventrally and inward. A small dorsal apophysis (Da) is present. Tegular apophysis (Tg) wide and protruding, axe-head shaped, with a basal triangular process

ventrally oriented (Tg-I). Terminal apophysis (Ta) with two laminar lobes shaped together as a narrow groove wrapping the tip of the embolus. Embolus (E) very long and filamentous, starting from the left side of the bulb and coiling around the cymbium, heading on the left side of the palp first backwards and then onwards with a U-shape (Fig. 5E). Terminal tip located in the frontal part of the palp. Conductor (C) long and wide, wrapped around the last part of the embolus and following its U-shape on the left side of the palp. Its basal part shows a laminar process (Cp-I) and its sharp lengthened apex (Ac) is bended prolaterally.

Female (one of the paratypes). Total length 2.04. Carapace length 0.95, width 0.78. Leg formula: I, IV, II, III. Leg measurements: I: 1.17, 0.37, 1.07, 0.98, 0.52 (4.11); II: 1.21, 0.36, 1.03, 0.77, 0.48 (3.85); III: 0.79, 0.35, 0.54, 0.57, 0.43 (2.68); IV: 1.25, 0.37, 1.02, 0.79, 0.51 (3.94). Habitus as in Figs 6E–F. Prosoma oval in dorsal view with two wide black stripes at the side borders and a dark elongated mark in the center. Palp with a long claw. Pattern and all the other characters as in the male.

Epigyne and vulva as in the Figs 6A–C. Epigynal plate (Ep) parallel to the abdomen, wide and flat with a roughly trapezoidal shape, the anterior edge wider than the posterior. The posterior edge can be considerably flat in some specimens. Insemination ducts (Id) with a screw-like shape, long and strongly coiled in several loops, extending from the copulatory openings to the spermathecae with a straight or approximately S-shaped route. Spermathecae (S) small and rounded, widely separated from each other.

Habitat. Litter of tropical seasonal rain forests.

Distribution. Known only from the type locality.

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